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EFFECT OF TITANIA NANO PARTICLES ON HYBRID FIBER BASED POLYMER NANO COMPOSITE

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ABSTRACT

In recent Engineering application composite material plays a vital role for their high wear resistant, good thermal stability, less weight. Among that Hybrid hierarchical polymer nano composites material is epitomize as a favourable materials for engineering applications. A structural investigation study on hybrid fibre(glass mat/jute mat/glass mat) by introducing nano size TiO_2 (Titania, 2–40 nm, 0,2,4,8% by weight) fillers into an polyester resin. An experimental investigation has been conducted on the prepared laminate to identify the mechanical behaviour of the material. The effect of TiO_2 particles on hybrid fibre(glass-jute) based polymer nano composites were studied. The synthesized titania nanoparticles are functionalized with γ-aminopropyltriethoxysilane and are mixed with polyester resin through ultra-sonication in different weight fractions as 0,2,4,8%. and the fiber-matrix impregnation was investigated using SEM analysis. The influence of titania nanoparticles on the mechanical behaviour like tensile strength and hardness were investigated. When the weight filler of TIO2 was increased, the tensile, hardness of the composite were increased.

Keywords: Titanium Oxide, Jute Mat, Glass Fiber, Polyester Resin, Mechanical Behavior, SEM

I INTRODUCTION

In the automotive field, building construction, water pipes, boat hulls, architectural, aircraft panels and stackable chairs, Unsaturated Polyester (UP) resins have been widely used due to their easy processing ability, high specific strength and modulus, low cost, light weight and recyclability. Glass fibre-reinforced polymer(GFRP) composites which has been widely used thermoset composite material. [3]. The overall mechanical behaviour of the composite material dramatically increases by the addition of particulate filler or elastomeric material to the polymer matrix as compared to the neat polymer. However, the degree of crosslinking in polyester networks leads to inherent brittle materials and that constraint many of its properties and applications. The interface boundary where these components meet is thus inherent to such materials, and the region near this interface is generally assigned as 'interphase'. The mechanical and physical properties change from the bulk properties of one component (glass) to the bulk properties of the other component (polymer) in this small region of the interphase. The load transfer from the matrix to the fibres occurs through this interphase region, so this it is very important to consider this segment for Glass Fibre Reinforced Polyester (GFRP) composite .The Jute fibre is Additional Reinforcement which has been added to this GFRP composite will enable a better mechanical behaviour of hybrid composite and also research is going on Nano composites to get superior properties when compared to conventional composites[10]. Nano composites are a class of composites derived from ultra-fine particulate inorganic particles, with sizes on the order of nanometres that are homogeneously dispersed in a polymer matrix. As addition of inorganic particulate particles to the hybrid composite get superior properties and also interfacial adhesion being maximized as compared to the conventional neat composite because of their nanometre size.[4-9].

The micron filled composites showed no increase in scratch resistance and a decrease in strain-to-failure relative to the neat resin[11]. TiO_2 is a key technological material and finds use in a large amount of applications, such as additives in plastics, agglomerates for thermal sprays, air/fuel ratio controller in automobile, attenuation of ultraviolet light, catalysts and catalyst supports, demilitarization of chemical and biological warfare agents, energy converter in solar cells, photochemical degradation of toxic chemicals, piezoelectric. TiO_2 has three specific advantages:

- (i) non-toxicity, chemical stability, corrosion resistant.
- (ii) good electrical properties, good compatibility with various materials, high,photocatalytic activity, high refractive index and ability to absorb ultraviolet (UV) light
- (iii) Due to these properties, TiO_2 nanoparticles have been used to transfer their excellent properties into coatings, in skin care products, in nano medicine, in lithium-ion batteries, in food packaging, in solar cells, in water purification, in gas sensors and in polymer matrix etc.

Several review articles have been extensively discussed TiO_2 thin films and TiO_2nanostructures[13].

However, the base polymer and its size depends on the the intensity of property modification, distribution and dispersion of the nanoparticles and on the adhesion at the filler matrix interface. Lot of research is going on and no work has been reported about the study of mechanical properties of HFRP-TiO_2 Nano composite in different weight fractions. the present work has been investigated on Glass and Jute as a reinforcement .and TiO_2 as filler material.

II.EXPERIMENTATION

2.1 Materials Required for Fabrication of HFRP-TiO_2 Nano composites

The commercially available TiO_2 of average size 50μm having purity 78.99% and density of 3.9 g/cm^3. The particle size was reduced to nano scale in a planetary ball mill for a period of 6 hours. Finally 30-40 nm size was obtained. It is organically modified with a γaminopropyltriethoxysilane (APS) by sonication process. Unsaturated polyester resin was used the entire process. It is pushed for ambient temperature and cure with addition of Methyl Ethyl Ketone Peroxide (MEKP) as catalyst. For hand lay-up applications it is convenient to promote the resin temperature to an ambient state and also for easy air release. when compared to other thermosetting resins Unsaturated polyester possesses many advantages including room temperature cure capability, good mechanical properties and transparency, low pressure moulding capabilities which make it particularly valuable for large component manufacture at relatively lowcost [14]. In contrast to other thermosettingresins, no by-product is formed during the curing reaction. Hence resins can be cast, moulded at low pressure and temperature [15].

2.2. Purpose of TiO_2 Nanoparticles

The mechanical propertiesof the composite materials are dependent upon the nature of interactions between the matrix and filler, however improvement of mechanical properties are obtained by the addition of material like TiO_2 the matrix interface. APS is used to disperse/exfoliate the TiO_2 nanoparticles in polyester matrix making use of an ultra sonicator. The compounding process was carried out with varying TiO_2 contents (0,2,4,8wt.%) and the technique was found highly efficient and environment friendly.

2.3. Synthesis of HFRP-TiO_2Nanocomposites

For the synthesis of HFRP-TiO_2nano composites the Hybrid fibre (glass/jute/glass) reinforcement such as woven roving (WR) is to be considered, and treated TiO_2nano polyester as a thermosetting resin material. The orthophalic polyester pre-promoted for ambient temperature with addition of (MEPK) a catalyst.TiO_2nano particle is treated with polyester resin was showed in fig1.(a)

Fabrication of HFRP-TiO_2nano composites was carried out using hand-layup technique.[16]. Fabrication of these composites are takes place at a room temperature. A fine smooth wooden mould was placed horizontally and coated with light layer of liquid polyvinyl acetate (PVA) as a release agent . Nano TiO_2 polyester resin was treated and soaked with a plain roller rolled over the mould surface to make the first layer of Nano TiO_2-polyester resin, followed by a layer of woven roving (WR) laid over the first layer of Nano TiO_2- polyester resin. Entrapped air between the layers was squeezed out during build up process, using a smooth steel roller, which also ensured that the polyester resin layers distributed uniformly over the surfaces. Then another layer of Nano TiO_2-polyester resin was applied over the glass fibre sheet. Then a layer of jute mat fiber is placed over the glass mat, and applied pressure evenly throughout the material for a clear bonding. Repeating the same step which we have made first were a glass fiber was used to built up to a thickness of 3mm and consisted of three layers of HFRP-TiO_2 hybrid fibres. The final HFRP-TiO_2 hybrid composite made by using hand layup was showed in fig1.(b) Keep the material under room temperature for a period of 24hrs. The above process is carried in different of treated TiO_2nano particles such as 2,4,8wt.% and also a sample prepared without the mixure of TiO_2 nanoparticles. For each Nano composite, five specimens were tested and the average value was taken.

Fig.1 (a) . Synthesis of HFRP-TiO_2 resin

Fig.1.(b) Nanocomposites by Hand- layup technique

2.4. Mechanical properties of HFRP-TiO_2nanocomposites

2.4.1 Tensile Strength

The sample specimens are subjected to tensile test for different wtpercents of TiO_2 for the WR as glass, Jute reinforcements, by introducing TiO_2 nanoparticles in various percentages as 2,4,8 wt. % by wt. Using a DAK - UTM at the cross head speed of 1mm/min according to ASTM D 638 as shown in Fig 2(b). For each composite, five specimens were tested and the average value was taken. The tensile strength is obtained from stress-strain curves. The model tensile specimens before conducting tensile test are represented in fig 2(a).

Fig 2(a).Tensile test specimens

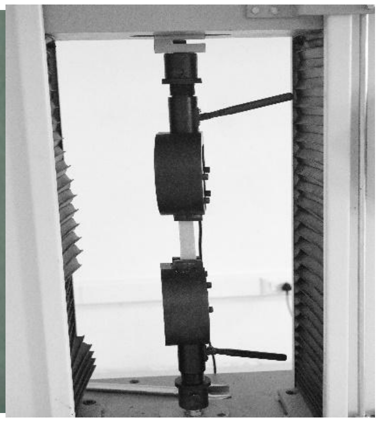


Fig 2(b). Specimen loaded at UTM

2.4.2 Hardness

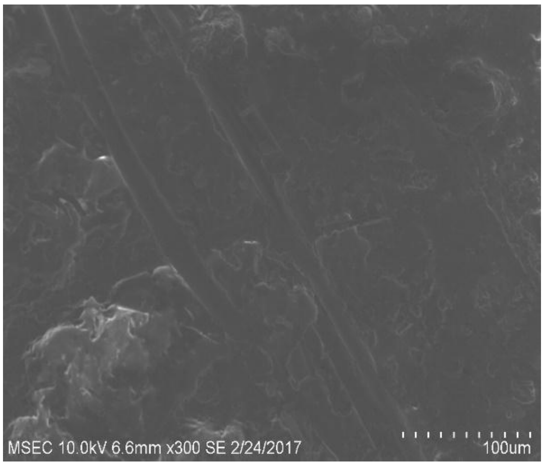
Hardness test was carried out using Rockwell Hardness testing machine. The specimen was placed under the indentor of the Rockwell hardness tester and a uniform pressure was applied to the specimen until the dial indicator reached a maximum. the average value was taken. These tests were carried out for different by introducing TiO_2 Nanoparticles in various percentages as 2%, 4%, 6%, and 8% by wt. to study the Hardness of HFRP - TiO_2nano composite. Testing specimens were prepared as per ASTM D-2583. The loaded specimen with Rockwell hardness testing machine was shown in fig 3.

Fig 3.Specimen loaded at Rockwell Hardness testing machine

III RESULTS AND DISCUSSION

3.1 Scanning electron microscopy (SEM)

The scanning electron microscopy (SEM) micrographs in Figures 3(a) and 3(b) shows the unfilled and TiO_2-filled HFRB composite systems, respectively. From the SEM images, the average fibre length for this fraction is estimated to be around 100µm as shown in Fig 3(a).Hybrid fiber with TiO_2 particles of polyester matrix is estimated to be around 50µmas shown in Fig 3(b) and It was found that TiO_2 particles were attached to the HFRB and to the stitching thread.Regarding the manufactured composites, weight contents of TiO_2 0,2,4,6,8wt% were all almost achieved. The micrographs show that the HFRB-TiO_2 Composites are well impregnated by the matrix, and with no apparent porosities as shown in Fig 3(b). The few lined white spots in the micrographs are believed to be due to fibres that have been pulled out from the surface during polishing which is shown in fig 3(a).



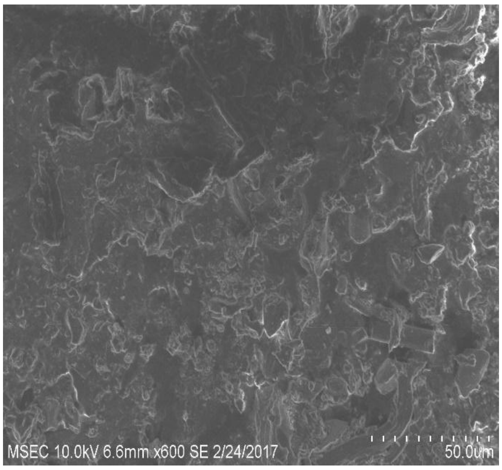


Fig 3(a) SEM image TiO_2 UnfilledFig 3(b)SEM image of TiO_2 filled

3.2 Tensile properties for HFRP-TiO_2 Nano composites for Different wt.%TiO_2 of Polymer

Hybrid(glass-Jute) Polymer composite which has no TiO_2 was subjected to tensile test, it is observed that Tensile strength for Pure has a value of 40MPa. When the material is reinforced with 2wt.% TiO_2 nanoparticles, tensile strength is increased to 77.36 MPa from the initial value of 40Mpa. A maximum value of 89.32MPa tensile strength is then observed at 4 wt.%, thus showing an improvement in Tensile strength of up to 55%. Later the Tensile strength is found to decrease by further reinforcement with TiO_2 nanoparticles beyond 4 wt.% and it reaches a value of 44.46 MPa by increasing the Nano TiO_2 to 8 wt.%.

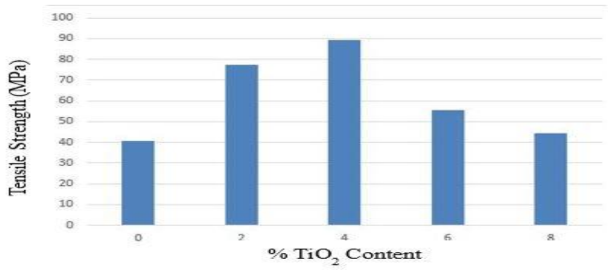


Fig 4. Comparision of tensile strength with different TiO_2 wt%

3.3 Hardness of HFRP-TiO_2nanocomposites

Experimental results showed that the Hardness is improved from 61 to 67 by reinforcing by 2% wt. nano TiO_2 and to 69 by reinforcing 4% by wt. nano TiO_2. Thus there is an improvement of 9.83% by reinforcing with 2wt.%nano TiO2 and there is an improvement of 13.11% by reinforcing 4 wt.% Nano TiO_2. It is evident that, there is not much difference in improvement of Hardness by reinforcing 2% and 4% by wt. of Nano TiO_2 and also that there is a decrease in Hardness values after 4 wt.%. Graphs plotted for Hardness Vs wt.%nano TiO_2 HFRP - TiO_2 Nano composites in which Glass-jute is used as reinforcement . This can also confirm that the wt.% of synthesis of the materials vary their Hardness, though they exhibit similar trend of path change in Hardness with addition of nano TiO_2 particles.

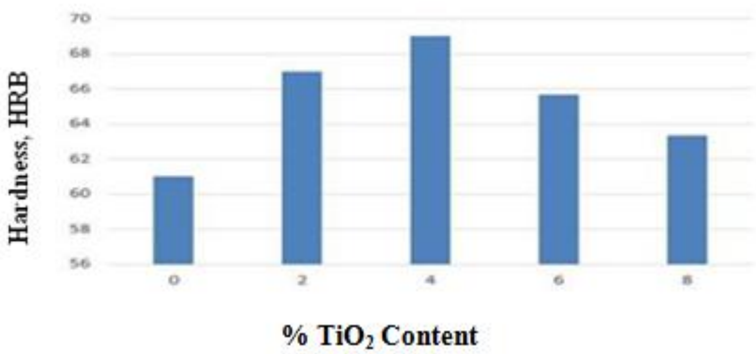


Fig. 4 Comparison of different wt. percentages between hardness and % nano TiO_2

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3.4 FTIR (Fourier transform infrared spectroscopy)

FTIR analysis was carried out in order to determine the modifications that occurred on the fibre surface due to their chemical structure. Compositional variation and physical organization at the microscopic level determine the ability to perform a desired function for most materials. In this fibre they can find out the transmittance capacity and absorbance capacity was determined and it is shows the Transmittance capacity with the wave number

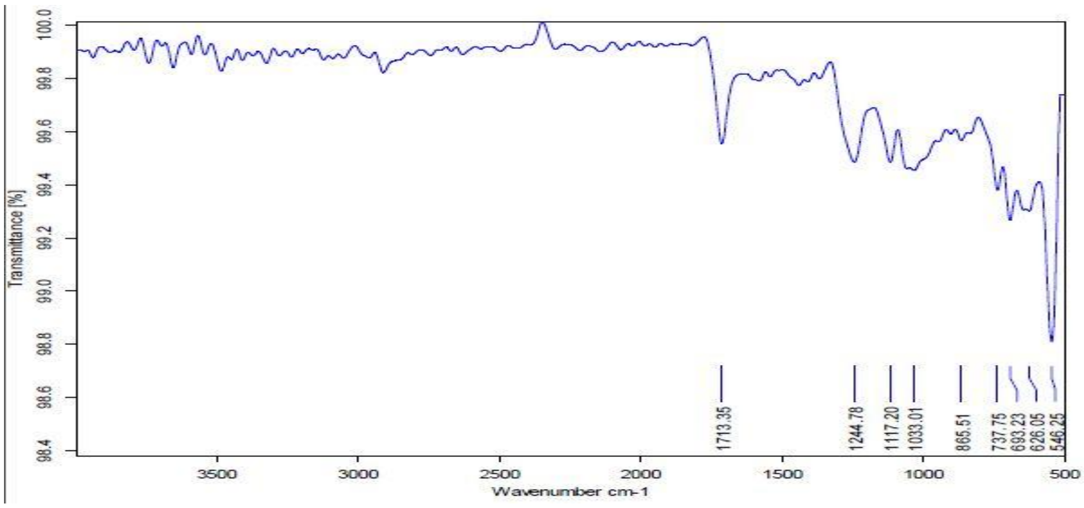

Fig 5 Hybrid fibre with TiO_2 Transmittance vs. Wave numbers

Fiber surface due to their chemical structure with FTIR results with TiO_2 are get plotted for wave numbers and transmittance is shown in Figure 5 and 6. From the plots the four high peak values are get noted for four bonds and intensity is specified for each bonds in Table 1 & 5 and It can be seen that the wave-numbers of peak position of hybrid fiber with TiO_2 are higher than those of Hybrid fibre without TiO_2. This indicates that the degree of adhesion between fiber and matrix is strong in matrix and reinforcement.

Table 1 Characteristic bonds of Hybrid Fiber with TiO_2

Type of Bond	Wavenumber cm^{-1}	Intensity
C=O stretching	1713.35	Strong
C=O stretch	1244.78	Strong
C-O-C asymmetrical stretching	1117.20	Strong
C-H ring and side group Vibrations	1033.01	Medium

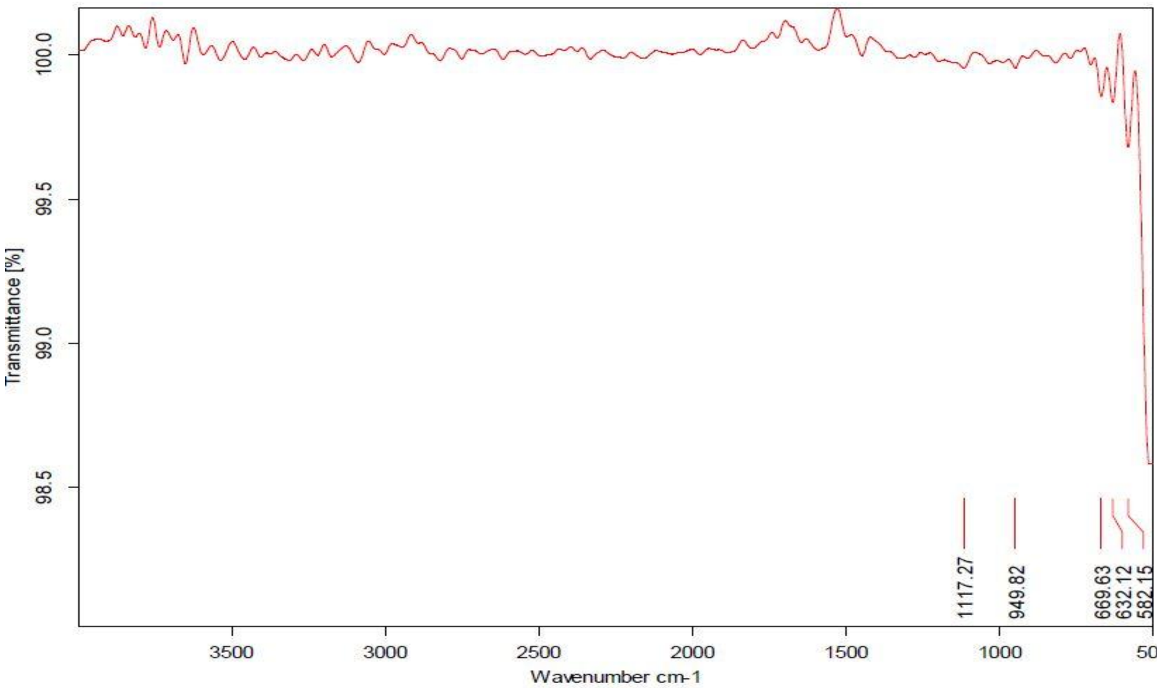

Fig 6 Hybrid fibre without TiO_2 Transmittance vs. Wave number

Table 2wavelength and peek intensity

Type of Bond	Wavenumber cm^{-1}	Intensity
C-O-C symmetric stretching,	1177.27	Medium
C-C, C-OH, C-H ring and side group vibrations	949.82	Weak
C-C, C-OH, C-H ring and side group vibrations	669.63	Weak
C-C, C-OH, C-H ring and side group vibrations	632.12	Weak

This decrease in wavenumber signifies an increase in the length of the covalent bonds involved in the vibration absorption, i.e. a decrease in the force constant of the bond due to the overlapping of bands, only two peaks can be seen in Figure 5.5. These results gave rise to a conclusion that HFRB with TiO_2 may have a clear anisotropic behaviour under mechanical stress, that is, their properties will be different in the longitudinal direction (along the fibre axis) and the transverse direction.

IV CONCLUSIONS

The HFRP Nano composites are synthesized with different wt.% of TiO_2 polymer with glass-jute as reinforcement of WR. In this specimen various tests conducted to determine the tensile strength, hardness, surface integirity, degree of adhesion between fiber and matrix was estimated. The analysis of experimental data has brought the following conclusions.

- The TiO_2 nanoparticles treated HFRP composite showed an intense effect on the mechanical properties of the material. The tensile strength and hardness of composites increased significantly by adding TiO_2 nanoparticles upto 4 wt% and further adding of TiO_2 nanoparticles decrease both tensile strength and hardness.
- The improvement of these properties by the addition of TiO_2 nanoparticles is due to the enhancement of fibre-matrix adhesion.
- The decrease of both tensile strength and hardness is due to agglomerates of TiO_2 nanoparticles.
- The agglomerates of TiO_2 nanoparticles can be the points of stress to damage the structure of the polymeric matrix, which results in decreasing of mechanical properties.

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